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LEARNED BY EXPERIENCE. RHYTHM OF LOAD ON TECHNICAL MAINTENANCE --ETC(U)
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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

LEARNED BY EXPERIENCE. RHYTHM OF LOAD
ON TECHNICAL MAINTENANCE UNIT

by

V. Lysov, Yu. Bardin, V. Kutlikov

FOREIGN TECHNOLOGY DIVISION

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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, , e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	*α*	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Τ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	*ϰ*	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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LEARNED BY EXPERIENCE

RHYTHM OF LOAD ON TECHNICAL MAINTENANCE UNIT

Engineer Lieutenant-Colonel V. Lysov, Candidate of Technical Sciences; Engineer Lieutenant-Colonel Yu. Bardin; Engineer Lieutenant-Colonel V. Kutlikov

The problem of the rhythmical work of a technical maintenance unit (TMU) in the course of a year is becoming quite acute. It is no secret that during the winter the TMU has a significant underload. In the summer we see a very different pattern. Routine maintenance must be performed on a large number of airplanes. The chief of the TMU finds himself in a difficult position, since required labor

expenditures for routine maintenance $T_{потр}$ considerably exceed the available $T_{расп}$. The overload on personnel is unavoidable. But this is not the only problem. The engineer cannot risk lowering the percentage of serviceability in the aviation equipment. All of this can be illustrated in the diagram below (Fig. 1). Such a pattern has been observed in one fighter-bomber TMU. Can an engineer reconcile himself to the situation? Of course not.

Another engineer may cite objective reasons. Let us say the commander has confirmed an annual plan for the accrued flying time of the unit and the mean annual flying time for each airplane has been established. We believe that this engineer is quite wrong. He is responsible for assuring an established accrued flying time, but simultaneously he must also consider how best to plan the rhythmical operation of the TMU. For such planning the engineer has all the raw data. He knows the accrued working hours and remaining service life of each aircraft at the beginning of the next year. He knows the plan for accrued flying time of the unit, the calculated removal of aviation equipment for repairs, and time and labor norms for performing routine maintenance.

How can we assure an even load for a TMU over an entire year?

Look at the diagram (Fig. 1). Can't we avoid periods of time

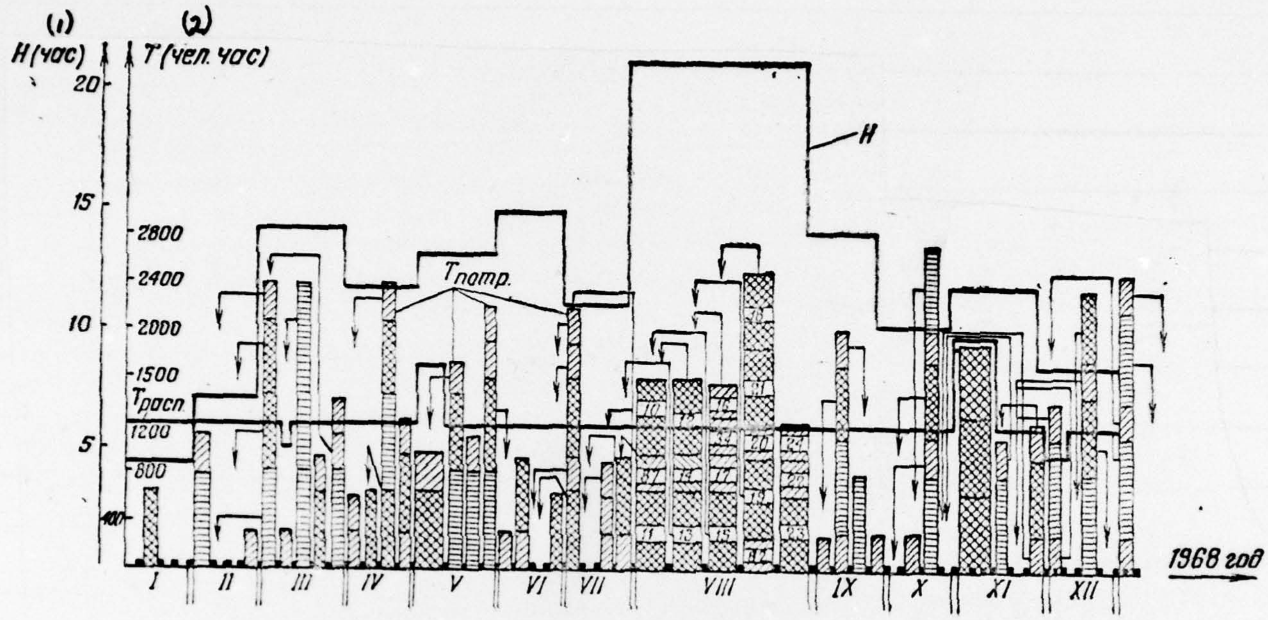

Fig. 1. Graphics and diagram showing load on TMU during course of one year: H - mean monthly flying time of one airplane; $T_{расп}$ - available labor expenditures of TMU in man-hours; $T_{потр}$ - required labor expenditures of TMU for ordering operations. Key: 1) hour, 2) man-hour.

when for several weeks more than three airplanes are coming in for routine servicing? In the given case three airplanes is an optimal TMU load.

Let us attempt to change the time that airplanes arrive at the TMU for the first routine maintenance in a studied year. The problem is quite realistic.

On several aircraft we could perform the first routine maintenance operations 15-20 hours before the assigned time, for example. Here we use a conditional figure. The engineer can correct it, since he knows the planned accrued flying time of each aircraft over the period of a week, a month, and a year. All this makes it possible to redistribute the times that airplanes enter the TMU within the course of a year. Thus, we can achieve uniform work in the TMU for the course of an entire year without crisis or breakdowns. Of course, the first routine maintenance operations on some airplanes within the studied year will be performed not within the prescribed 50, 100, and 200 hours of flying time, but earlier, for example, within 44, 89, or 185 hours.

Now let us propose the following method for compiling a plan of operations for the TMU in the course of one year.

Knowing the time norms for performing routine maintenance and the number of airplanes, we plot a graph of required labor expenditures $T_{потр}$ for the entire year. On the same graph we plot a curve for available labor expenditures $T_{расп}$ in the TMU (also by the week). The $T_{расп}$ diagram is plotted from the data of the available reserve of working time of the TMU personnel for operations on aviation equipment only (i.e., excluding labor expenditures for repair, finishing opertions, duties, etc.). Now we clearly see the disparity between required labor expenditures and the reserve working time available in the TMU.

The actual time that the airplanes enter the TMU is registered in the form of rectangles, whose height corresponds to labor spent on performing the routine maintenance operations of a corresponding periodicity (routine maintenance operations of the same periodicity should be marked in one color or by appropriate hatching, as done in Fig. 1).

In the rectangles we record the numbers of the airplanes. Under the diagram we note the overall accrued flying time of each airplane at the beginning of all routine maintenance operations and the remaining service life up to the next routine maintenance. On the X-axis we write the average flying time in the month and week (it is assumed that all airplanes fly uniformily).

Finally, we redistribute the times that all airplanes enter the TMU in the course of a year in order to eliminate the disparity between required labor expenditures and available labor expenditures. Thus, we shift the beginning of the first routine maintenance operations of the year toward lower intermaintenance periods. Into the free places on the diagram we shift routine maintenance operations on other aircraft from the three periods of the year corresponding to the overload on the TMU. However, here the following question arises: How many hours earlier can we begin the first operations so as, on one hand, to subsequently liquidate the crisis and, on the other, do this without spending too much in labor for earlier performance of these operations. Thus, we rearrange the system primarily for the purpose of liquidating the portions of prolonged overload on the TMU.

Obviously we must preserve nominal periods between maintenance. After all, if we shift the times that certain airplanes are removed for routine maintenance operations out of the overloaded parts of the year, then we must also shift the times that these airplanes arrive at the TMU both before and after the given moment. In other words, we must consider the consequences of our corrective measures to avoid creating a crisis situation in another part of the year. It is clear

that this rearrangement of the system is possible if the flying time in the year, month, and week is known and under the condition that the airplanes do not leave the unit or have prolonged down time due to improvements, breakdowns, etc.

This is all very well, but one might ask : On what airplanes could the first routine maintenance operations be begun earlier than the established times at the beginning of the year? Here the following conditions can serve as a guide. The first of these is written as a simple formula: $T_{\text{потр}} \leqslant T_{\text{расп}}$ or $T_{\text{потр}} = T_{\text{расп}} + E$, where E is the preassigned permissible quantity by which $T_{\text{потр}}$ exceeds $T_{\text{расп}}$.

Further, the percent of serviced airplanes must not be lower than the assigned. This is our second condition. And, finally, there should be, to the extent possible, the optimal number of airplanes for simultaneous work in the TMU (three in the studied case).

Now let us specify the parts of the year corresponding to prolonged overload on the TMU. In our case this is August and the second half of May. Thus, we first analyze the possibility of unburdening the TMU during these periods of the year. Liquidation of TMU overloads at other periods in time, when these overloads are short-term, is a secondary problem. The solution to this problem depends on rearranging the system in the portions of the prolonged

overload. Of course, if at one place we shift the time that a certain airplane enters the TMU, then we must make an approximately corresponding shift in the time that the same airplane is sent in for preceding and subsequent maintenance operations during the year.

First let us look at the right end of the very last portion of prolonged TMU overload in the year. We know that the TMU must have at least m airplanes simultaneously, more according to the diagram. Moreover, $T_{\text{потр}}$ considerably exceeds $T_{\text{расп}}$. Therefore, in order to bring $T_{\text{потр}}$ and $T_{\text{расп}}$ into agreement without diminishing the percent of serviceable airplanes, routine maintenance operations on one or several airplanes must be begun a little earlier (one or two calendar weeks) then the assigned time.

In our example, in order to unburden the fourth week in August, we move the time for performing routine maintenance operations on airplanes Nos. 18 and 19 up by 1 and 2 weeks, respectively. However the 2nd and 3rd weeks of August are already overloaded. Therefore, on airplanes Nos. 16 and 15 routine maintenance operations also begin 1 and 3 weeks earlier. Now let us look at the second week in August. It is obvious that routine maintenance operations on airplanes Nos. 12 and 13 should be moved to the first week of August. As for airplanes Nos. 10, 11, and 87, they will enter the TMU in the 3rd, 2nd, and 4th weeks of July, etc. (not in the first week of August, as planned

earlier).

Thus, we have liquidated the TMU overload in the heaviest period. Incidently, note that from the summer months it is not wise to move operations of great periodicity, for example, 200- and 400-hour operations, since it is very difficult to find a place for them in nearby, and usually fairly loaded, weeks.

It is much easier to maneuver the 50-hour and 100-hour routine maintenance operations.

Now we are left with the task of liquidating crisis in other portions of the year. Here, in making further time shifts consideration is given to shifts already made. This means that the periods between maintenance must be approximately equal to the nominal value everywhere. For example, we have shifted to the left the time for performing operations on a given airplane in August. Now we must make a corresponding shift in all preceding and subsequent times for operations on this same aircraft. This is easy to do, since the periods of time when the TMU is overloaded are frequently separated from one another by time intervals in which the is virtually no load or is not completely loaded. In our example such time intervals are the 2nd and 4th weeks in December, the 1st, 2nd, and 4th weeks of October, the 3rd week of November, and almost all of

January and February.

The arrows in Fig. 1 indicate rearrangement of the system for the purpose of moving the diagram for required labor expenditures and bringing it into agreement with available labor expenditures.

In rearranging the diagram certain deviations from the nominal between-maintenance period is possible with respect to plus or minus allowances. For example, for 200-hour routine maintenance operations we can permit deviation of up to ± 5-6 hours, for 100-hour operations - up to ± 3-4 hours, for 50-hour operations - up to ± 1-1.5 hours. The engineer can use the remaining tolerance reserve in a case where for different reasons there might be a change in the plan for removal of airplanes for routine maintenance. Moreover, the plan is created to be accurate to within one week. For this reason the engineer can also make variations in the days of the week. He can also change to a certain extent the annual diagram for conducting routine maintenance operations on aircraft without recalculating the entire scheme.

Hence, we get a new system for even distribution of the load on the TMU over the course of an entire year. Figure 2 shows the obtained diagram for labor expenditures required for conducting routine maintenance operations by the week. We see that only in some period do required labor expenditures slightly exceed those available

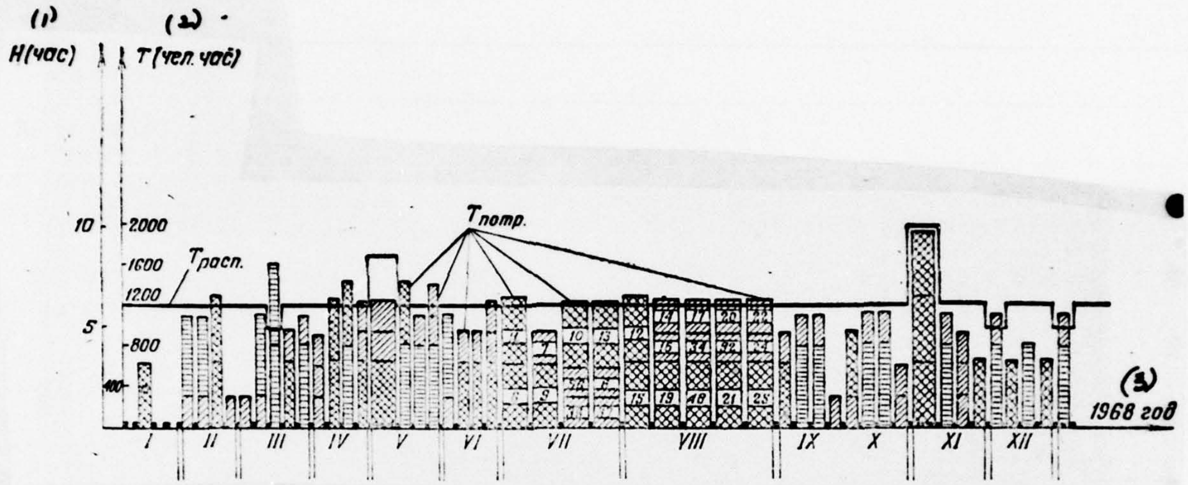

Fig. 2. Corrected scheme and diagram for TMU load. Key: 1) hour, 2) man-hour, 3) year.

to the TMU fund. It is probably possible to get an even better diagram than the one in our example.

Such a system should be plotted for 3-4 years in order to detect and prevent inadmissible cases of redistribution in the times that operations are performed, which result from a massive diversion of airplanes for preventive and major repair (maintenance). The obtained system for sending airplanes in for routine maintenance over the course of one year can be easily adjusted each month by a corresponding shift in the rectangles. By thus considering actual deviations from the plan for accrued flying time for the unit in the preceding month, as well as unforseen down time for individual aircraft undergoing repair, improvements, etc., the engineer can be assured that he will not be faced with crises in the TMU in the final months of the year.

Uniform operation of the TMU in the course of a year has, of course, a great number of unconditional advantages. Yet this is achieved by carrying out certain operations earlier, i.e., we must become reconciled to a certain overexpenditure of labor for routine maintenance operations during the year. Now let us estimate the increase in required annual labor expenditures for routine maintenance.

For this we must calculate how many hours earlier than the formerly assigned periods must routine maintenance operations be performed on each of the aircraft in the studied year. Then, for each aircraft labor spent to perform these operations is divided by the periodicity of the same operations, i.e., we get labor expenditures per one hour of flight time.

The obtained relationship must be multiplied by the number of hours, calculated above, by which the first routine maintenance operations for each aircraft in the studied year precede the formerly established time (remaining operations are performed according to plan with respect to nominal periodicity).

The sum of these quantities gives us the unknown increase in labor spent in making the transition to the new system for planning times for diverting aircraft to routine maintenance operations. It is expressed by the following formula:

$$T_{yв} = \sum_{i=1}^{n} T^{i}_{pp} \frac{\delta_i}{\tau^{i}_{pp}},$$

where T^{i}_{pp} is labor spent on performing the first routine maintenance opertions in the studied year on the i-th airplane; τ^{i}_{pp} - periodicity of these operations; δ_i - shift toward beginning of year of first routine maintenance operations in studied year according to new system on each aircraft as compared to old plan (in hours); n -

number of airplanes.

Finally, in order to facilitate correction of the plan after each month's work of the unit it is recommended that a planning and assembly slate of different colored rectangles corresponding to operations of each periodicity and indicating the number of the airplane be compiled. On the slate the axis of calendar time for the studied year must be indicated. The advantages of such a slate are obvious. First, the diversion of airplanes for routine maintenance - both existing and planned for the following weeks and months is graphically visible and, second, at any time the engineer can introduce corrections in the plan by rearranging the rectangles.

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